Airport & Aircraft Safety R&D Notes

Volume 1, Issue 3 | FAA's Airport & Aircraft Safety R&D Division | April 2000

Deicing Facility Dedicated

In 1994, the Federal Aviation Administration Technical Center began a partnership with a small Buffalo, NY, firm that had an idea for deicing airplanes that went against conventional wisdom. Process Technologies, Inc. (PTI) had a total of three people, a hand-held contraption that melted ice cubes in a Buffalo garage, and an enormous amount of enthusiasm and perseverance.

On February 15, 2000, PTI (now known as Radiant Energy Corporation) officially opened an infrared deicing facility for Continental Airlines at Newark International Airport. This facility is large enough to deice aircraft in the Continental fleet up to and including a Boeing 757.

The technology behind this innovative system is as old as the sun itself. It uses infrared energy to warm an object in the same manner as the sun warms your skin on a cold winter day. Specially designed burners heat pipes to a point at which they emit infrared energy tuned to the absorption range of ice. This energy behaves like a beam of light, except that it warms rather than illuminates objects in its path.

The FAA's Technology Transfer Team of jennelle Derrickson, Marie Denan, and Pete Sparacino put together a Cooperative Research and Development Agreement (CRDA with PTI in

Boeing 757 inside the Newark infrared deicing facility

1994. This CRDA gave Jim White, AAR-411, the opportunity to comb the Technical Center for people and resources to fuse with the industrial expertise and fiscal resources gathered by PTI.

Senator Frank Lautenberg (D-NJ) cuts the ribbon on the new facility.

Over the next three winters Armando Gaetano and test pilots Mark Ehrhart and Keith Biehl (ACT-370) provided a mix of FAA test aircraft for a series of deicing demonstrations. White, Gaetano, and the pilots worked many frigid nights in

INSIDE THIS ISSUE

Buffalo and Rochester, NY, with the PTI crews as they demonstrated to the aviation community the effectiveness of their deicing system. Every step of the way the imaging specialists from ACT-073 captured the events on film and videotape.

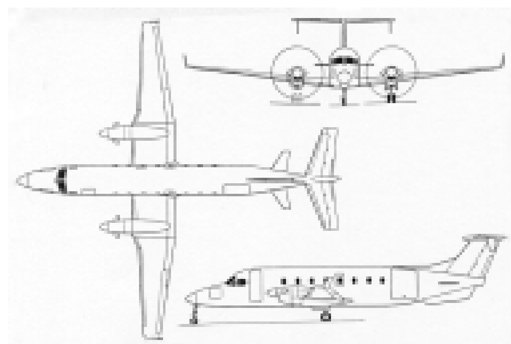
Dale Dingler (ACT-73), Marie Denan (AAR-400), Ron Meilicke (ACT-73), Jim White (AAR-410), Bob Maier (Radiant Aviation Services), jennelle Derrickson(AAR-400) , and Pete Sparacino (AAR-400) pose next a Boeing 757 inside the infrared deicing facility.

The Newark facility is the third infrared system to go on-line. Buffalo claims the first system (1997) followed by Rhinelander, Wisconsin (1998). These facilities are sized for business and commuter airplanes. With Newark, infrared deicing has moved up to the big leagues. All three provide a chemical-free method for deicing aircraft.

Although the CRDA with PTI is completed, the dividends continue. There is one more FAA chapter to this story. George Legarreta (AAS-100) is preparing the Advisory Circular language that will make systems like the one at Newark eligible for Federal support. Airports across the country (and the world for that matter) now have another way to keep winter flight safe for both the passenger and the environment. Point of contact: Jim White, AAR- 410, (609) 485-5138.

Preliminary Results from the BE-1900D Operational Loads Monitoring Program

During the decade of the 1990s, there was a strong interest worldwide in characterizing the actual loading environment experienced by aircraft in typical operations. Most attention to date has been given to large transport aircraft, although there has been some data collected for special situations, and general aviation aircraft. Until recently, there has been little, if any, statistical loads data collected for a rapidly growing segment of operational flight operations namely, commuter operations.



Commuter Turboprop

Commuter turboprops have been in operation for many years. However, it is only recently that the market share of these operations has begun to grow substantially as air carriers centralize large transport operations at “hub” airports, relying on supplemental commuter operations to feed passengers from outlying areas to these central operations hubs. The increased presence of these types of operations has led to the emergence of several successful entries into the “regional jet” market — an essentially new type of aircraft operating at the ragged edge of FAR Part 25 applicability. Thus, it is important that FAA, and the aviation community at-large, have a clear characterization of the flight profiles and the external loads environment encountered in commuter operations.

The findings of a preliminary statistical loads survey of commuter operations are summarized in the table below. The data were collected from digital flight data recorders (DFDRs) on 28 BE-1900D turboprop aircraft, representing 903 flights and approximately 585 hours of operation.

Maximum Taxi Weight Maximum Take-off Weight Maximum Landing Weight Zero-Fuel Weight Empty Weight	17,060 lb. 16,950 lb. 16,600 lb. 15,000 lb. 10,350 lb.
Fuel Capacity	668 U.S. gallons
2 P&W PT6A-67D Turboprops	@ 1,279 shp each
Wing Span Wing Reference Area Wing MAC	57 ft 11.25 in 310 ft^2 5.32 ft
Length Height Tread Wheel Base	57 ft 10 in 15 ft 6 in 17 ft 2 in 23 ft 9.5 in

- Large differences in measured gust load factors between the commuter type aircraft and the large transport aircraft were found but were accounted for by the differences in the load factor response of each aircraft.
- Maximum airspeed limits at various altitudes as defined in the Type Certificate of the aircraft were occasionally exceeded.
- Since derivation of derived gust velocity requires knowledge of the aircraft's gross weight, it is recommended that future data include at least the aircraft takeoff and landing weight.
- Additional instrumentation to record related parameters such as gross weight, fuel weight, lateral acceleration, and Mach number should be installed to provide more in-depth and accurate information to the user of these data.
- Installation of a squat switch and these additional parameters is highly recommended.
- Additional data on turboprops need to be collected and processed for a more reliable characterization of typical in-service usage.

Further details can be found in the FAA Technical Report "Statistical Loads Data for BE-1900D Aircraft in Commuter Operations," January 2000. Point of contact: Thomas DeFiore, AAR-433, (609) 485-5009.

FAA/AANC NOTES

Visual Inspection Reliability Program

The FAA Airworthiness Assurance Nondestructive Inspection (NDI) Validation Center (AANC) is currently conducting a visual inspection study to explore the effects of instructions on visual inspection performance and reliability. The study is being conducted using the FAA's B737 testbed, located at the facility, and builds on the benchmark study conducted in 1996. Six versions of work instructions have been developed, based on actual airline workcards, for each of six on-aircraft inspection tasks. These instruction versions vary in the number and types of directed callouts. Each inspector conducts all six inspections and uses each instruction type once. Results will allow the impact of varying instruction content on search strategy and inspection performance to be determined. Forty-two inspectors from a number of major airlines are scheduled to participate in this study, with 12 inspections already complete. Inspections should be completed this summer. Point of contact: Caren Wenner, AANC, (505) 284-5220.

Rotorcraft Program

The AANC developed a test facility to subject structures to simultaneous torsion and axial loads and provide an automated application of flight load spectrums. Phase II fatigue and NDI testing is underway on a series of composite rotor hubs. The specimens mimic the critical load-carrying portion of the hub that connects the rotorcraft blade to the engine mast. Ultrasonic inspections accompany the fatigue tests to study inspection of thick composites in light of their damage tolerance. In a separate task, the AANC completed a joint effort with Bell Helicopter to detect corrosion in helicopter joints. A dual frequency eddy-current inspection procedure was developed and validated to quantify exfoliation levels in thin gauge skins (0.016″ - 0.025″ thick) of two-and-three layer stack-ups. Typically, corrosion detection in helicopters requires extensive and costly teardown and overhaul of frame members. Without a nondestructive inspection method of evaluating the fraying surface of lap joints and structures before overhaul, unnecessary person-hours and money may be spent. Furthermore, the application of noninvasive NDI for early corrosion detection could produce increased aircraft safety and reduced repair costs. A corrosion detection study showed that over 80% of the flaws, including 95% of those above the required detection threshold, were found. In addition, the level and shape of the corrosion sites were correctly identified almost 90% of the time. Field testing of the dual frequency inspection method will soon be initiated at commercial and military maintenance depots. Point of contact: Dennis Roach, AANC, (505) 844-6078.

Liquid Penetrant

The AANC is currently conducting experiments with Level 4, Method B penetrant on low-cycle fatigue cracks in titanium (Ti-6AL-4V). The main focus of these experiments is to document the affect of penetrant brightness by varying inspection parameters such as drying temperature, drying time, and dwell time. It was discovered that the low-cycle fatigue cracks simulate the basic interaction between a liquid and solid interface. This interaction is responsible for the migration of the penetrant into the surface cracks. By increasing the drying temperature from 125°F to 145°F, there is not enough temperature change to affect penetrant viscosity. However, at 165°F the penetrant viscosity decreases and the brightness values are affected on both deep and shallow cracks. Brightness values decrease rapidly as drying temperature approaches the upper temperature limit. The change in penetrant viscosity causes more penetrant to bleed out of the crack before the developer is added. By doubling the post-emulsifier times, the emulsifier is allowed to diffuse deeper into the crack. However, at some depth from the inspection surface the concentration of the emulsifier becomes so weak that it does not affect penetrant deep in a crack. This FAA penetrant program is continuing to study the penetrant interaction with low-cycle fatigue cracks. As AANC develops a better understanding of liquid to metal interaction, it will continue to document the experimental results. Future work will repeat these experiments with different penetrant sensitivities, types of applications, and different inspectors. Point of contact: David Moore, AANC, (505) 844-7095.

NDI Capability Assessment

The AANC is currently developing a capability assessment methodology that can be used to assess new technologies and new NDI procedures. The goal of a capability assessment, as opposed to a reliability assessment, is to determine whether a specific technique or process has even the basic capabilities needed for aircraft inspection. As a first step in this process, a database of NDI procedures that are performed in the aircraft industry has been developed. This database, compiled from a review of airline maintenance documentation, has been used to determine the characteristics of typical inspections (e.g., materials, geometry, defect type, and size) that a new technology or process must be able to perform to be used for typical aircraft inspections. Test specimens and reference standards are being purchased and/or fabricated to ensure that the AANC Test Specimen Library has the necessary specimens for the full range of these inspections to be tested. Plans are to implement a candidate technology through the process. Furthermore, a guide to Human Factors in NDI has been developed, which includes a checklist-based tool that can be used to evaluate human factors issues in the application of NDI equipment. Point of contact: Caren Wenner, AANC (505) 284-5220.

Assessment of Aging Characteristics of Electrical Insulation

The AANC has initiated a program to evaluate the aging and durability of electrical insulation used in commercial aircraft. As a part of the FAA's intrusive inspection program guided by the aging systems taskforce, Sandia Labs will examine cable bundles obtained from various locations of eight different retired commercial aircraft. Sandia will bring technical expertise and techniques that have been developed during the past two decades for assessment and lifetime prediction of cable insulation in a wide range of "high consequence" Department of Energy defense and energy applications, as well as in commercial uses. Sandia will evaluate the applicability of approximately 10 specialized laboratory techniques which have been used in the past to assess cable materials degradation and to establish the applicability of the various techniques to the types of insulation used in commercial aircraft. Selected techniques will then be used to examine field-returned cable bundles to detect evidence of any aging-related changes in the materials. The AANC will also coordinate additional cable reliability testing to be performed by other laboratories. The second year of the program is envisioned to include the initiation of laboratory accelerated aging experiments, an assessment of the implications of aging characteristics, and identification of key environmental effects on aircraft cables. Point of Contact: Roger Clough, Sandia National Labs, (505) 844-3492.

In Brief

Electromagnetic Hazards to Aircraft. Anthony Wilson, AAR-421, participated in a meeting of the Society of Automotive Engineers (SAE) AE-2 lightning committee on March 7-9 in Orlando, Florida. The two currently active FAA-sponsored research programs were reviewed. Martin Uman and Keith Rambo from the University of Florida presented current results of their investigation characterizing lightning as it interacts with aircraft systems. The work involved compiling existing data, conducting triggered lightning measurements, and characterization of lightning strikes. The investigation is on schedule and will continue into next year. Andy Plummer from Lightning Technologies, Inc., presented the status of the airline lightning strike reporting program. The completed lightning strike database was reviewed by the Electromagnetic Effects Harmonization Working Group (EEHWG) executive committee and will be provided to AAR-421 for FAA disposition. The FAA National Resource Specialist for Electromagnetic Effects reported that the next step for the EEHWG lightning advisory material package is to undergo FAA legal and economic reviews. After the reviews, the documents will be returned to EEHWG for final approval. The committee expressed appreciation for the presentations and endorsed the FAA lightning research plan and progress. The next SAE AE-2 meeting will be held on June 6-8 in Montreal, Canada. Point of contact: Anthony Wilson, AAR-421, 609-485-4500.

Initial Evaluation of Smoke Transport in Cargo Compartments. A meeting was held at Sandia National Laboratories in Albuquerque, NM, to discuss the initial stages of their work to develop models for the transport of smoke during a cargo compartment fire. Sandia is modifying the VULCAN fire field model code to predict the temporal and spatial distribution of temperature, gases, and soot particles during three classes of smoldering (nonflaming) fires inside a cargo compartment. The predictions will be compared with experimental data generated by the FAA in the B707-cargo compartment. The ultimate application of the models is to provide guidance on the location of cargo compartment smoke detectors and to assist in the design of certification flight tests to show compliance with detector response rate requirements contained in FAR 25.858. A draft report entitled, "Initial Evaluation of Smoke Transport Phenomenon in Aircraft Cargo Compartment," coauthored by Sandia personnel and Dave Blake, AAR-422, was reviewed. The work is funded by the NASA Aviation Safety Program and is administered and technically monitored by AAR-422. Point of contact: Gus Sarkos, AAR-422, (609) 485-5620.

Aircraft Icing. Richard Jeck and Manuel Rios of the Flight Safety Research Section participated in an Icing Specialists Meeting hosted by the NASA/Glenn Research Center in Cleveland, Ohio, March 21-22. The meeting was in support of the internationally staffed Ice Protection Harmonization Working Group (IPHWG), which has a task to devise requirements for assessing the ability of aircraft to operate safely in freezing drizzle or freezing rain conditions, commonly referred to as supercooled large drop (SLD) conditions. Richard Jeck is assembling a database of SLD measurements from a number of dedicated research flights over Europe and the Americas, and Manual Rios is involved in icing wind tunnel experiments and in the development of a new icing spray tanker aircraft by the U.S. Air Force. The Icing Specialists Meeting was for (a) discussing possible engineering standards for SLD conditions, (b) assessing the available instrumentation for measuring SLD, and (c) deciding what to do about current shortcomings in producing SLD sprays in icing wind tunnels and in computer modeling of SLD icing effects on aircraft wings. The outcome was a plan for interested computer modelers and icing wind tunnel operators to follow in developing SLD simulation capabilities. Richard Jeck and others analyzing the available SLD data will suggest representative SLD conditions for icing wind tunnels to try to produce. Point of contact: Richard Jeck, AAR-421, 609-485-4462.

Preliminary Evaluation of Aviation Safety Risk Analysis Technical Support Performance Measures and Risk Indicators by Airline Personnel. One of the tasks in the Aviation Safety Risk Analysis Technical Support (ASRATS) project is to facilitate subject matter expert evaluation, both internal to the FAA and external of the initial subset of Performance Measures (PMs) and Risk Indicators (RIs) that were developed at a high level across the entire oversight system and at a detailed level for the maintenance activity. Four people, representing four airlines, participated in an evaluation of ASRATS, PMs, and RIs. The objectives of the proposed evaluation and feedback exercise were to involve airline operational entities in evaluating the development methodology and the initial subset of PMs and RIs with respect to

- Effectiveness: the degree to which the process output (work product) conforms to requirements. (Are we doing the right things?)
- Efficiency: the degree to which the process produces the required output a minimum resource cost. (Are we doing things right?)
- Quality: the degree to which the product or service meets requirements.
- Value: the value added by the process to the safety of the organization, the working environment of its employees, and the air carrier's customers.
- Comprehensive: whether there is sufficient inclusion of detail to meet the objectives.
- Logical Architecture (decomposition strategy): if the format, terminology and definitions provide coherent and consistent information. Identify strengths and weaknesses, (e.g., areas that have been overlooked) of the approach and PM/RI subsets.

The participants were extremely supportive and willing to provide feedback on the approach as well as discuss how the subject related to their individual organizations. They also agreed to a follow-up session, during which there will be a review of the evaluation pertaining to PMs and RIs, and an evaluation of the corresponding data objects. Point of contact: Kathy Fazen, AAR-424, (609) 485-4100.

Fuel Tank Inerting Flight Tests. In a significant development, Boeing has offered to work with the FAA to conduct ground-based fuel tank inerting flight tests in a Boeing 737-800-NG-BBJ (Next Generation, Boeing Business Jet). Basically, the purpose of the ground and flight tests would be to determine the retention of inerting conditions in the center wing tank (CWT) by measurement of oxygen concentrations during a series of ground and flight conditions that would tend to promote CWT ventilation and possible reduction in the level of inerting. At the request of the Transport Airplane Directorate, the Fire Safety Section is developing and will be procuring the oxygen gas analysis instrumentation package and will participate in the ground and flight tests planned for early May. Point of contact: Gus Sarkos, AAR-422, (609) 485-5620.

During a 2 week period beginning March 6, AAR-421 personnel participated in a joint test program among the FAA, NASA, BFGoodrich, and the University of Illinois at Urbana-Champaign to study and document intercycle ice accretion on a NACA 23012 airfoil section with pneumatic boots on the leading edge. Pneumatic boot deicing systems are commonly used on commuter aircraft to remove ice periodically from wing and tailplane leading edges. Not all ice is shed cleanly when the boot fires; however, and the roughness remaining provides accretion sites for additional buildup before the next boot firing. The intercycle ice data collected during this test will be used for future aerodynamic testing to determine the effects of the intercycle ice on aerodynamic performance. Point of contact: Chris Dumont, AAR-421, (609) 485-6663.

Inspection Systems Research. During the week of February 21, personnel from the FAA Airworthiness Assurance NDI Validation Center (AANC) conducted one in a series of Interlayer Crack Experiments at Northwest Airlines (NWA) in Minneapolis. The purpose of the experiment is to determine the effectiveness of the inspection equipment and procedures specified in Service Bulletin 737-53A-1177. The Service Bulletin describes a low-frequency sliding eddy-current method to detect cracks from fasteners in the second and third layers of the Boeing 737 lap splice. Northwest Airlines was able to provide 14 different inspectors from all three shifts to perform the experiment. To date, including NWA, 8 airlines and repair stations and 55 inspectors have taken part in the experiment. Although no schedules have been established, Continental Airlines has also agreed to participate in the experiment. A draft final report is due by this fall. Point of contact: Dave Galella, AAR-433, (609) 485-5784.

Announcement

The Airport and Aircraft Safety R&D Division 1999 Research and Development Highlights Report is now available. This report contains highlights of the major accomplishments and applications that have been made by Airport and Aircraft Safety Division researchers and by our university, industry, and government colleagues during the past year. The highlights illustrate both the broad range of research and development (R&D) activities supported by the FAA and the contributions of this work in maintaining the safety and efficiency of the national aerospace system. The report also describes some of the division's most important research and testing facilities, considered to be some of the most scientifically advanced in the world.

The Highlights Report, which is available on the Internet, includes fact sheets, an overview of the division's facilities, copies of technical reports published in 1999, and the proceedings of the 1999 Aging Aircraft Conference.

The Highlights package can be found at: http://www.asp.tc.faa.gov/acc/

Airport & Aircraft Safety R&D Notes

Coordinator

Jim Lignugaris

Branch Representatives

Hank Marek
Rosanne Weiss
Jim White

Airport & Aircraft Safety R&D Notes is published quarterly. If you have any questions about this issue, or have ideas for future articles, please contact the editor, Jim Lignugaris, at (609) 485-4431 or via email at jim.lignugaris@tc.faa.gov.